Appendix A

Summary of State of Colorado Study: Results of a Survey of Fortuitous Specimens and Soil Samples at Rocky Mountain Arsenal for Analyses of Trace Organic Contaminants, Arsenic, and Mercury

SUMMARY OF STATE OF COLORADO STUDY: RESULTS OF A SURVEY OF FORTUITOUS SPECIMENS AND SOIL SAMPLES AT ROCKY MOUNTAIN ARSENAL FOR ANALYSES OF TRACE ORGANIC CONTAMINANTS, ARSENIC, AND MERCURY

The CDPHE analyzed containerized waste from Basin F and various biota from RMA for trace organic compounds, arsenic, and mercury (EcoLogic 1996). The PCDD/Fs found in the Basin F waste and some of the biota samples led to the current Tier 1 Field Study. For ease of comparison, only the chemicals analyzed in the current Biological Advisory Subcommittee (BAS) study will be presented from the state-sponsored EcoLogic (1996) study. Given the screening objective of the study, the independent contract laboratory was not required to meet the data quality objectives and quality assurance procedures mandated for data collected in other Rocky Mountain Arsenal (RMA) studies.

Basin F Waste Samples

The waste samples collected from Basin F were containerized in 55-gallon drums and originally used by the state to estimate emissions that may occur during remediation of the Basin F waste pile (Schmidt and Winegar 1995; included as Appendix C in EcoLogic 1996). At the end of the air-emission study, left-over waste samples from each drum were stored in state freezers.

Basin F was an asphalt-lined disposal basin that received liquid waste from 1956 through about 1986. In an attempt to minimize seepage of liquid wastes into the shallow groundwater-flow system, liquid wastes from most of RMA were consolidated into Basin F, the first lined basin at RMA. In 1989, the liquids were temporarily transferred into Ponds A and B and a tank farm, located immediately north of Basin F. The liquids were then ultimately destroyed in the submerged quench incinerator. Through evaporation of the liquids in the uncovered Basin F, chemicals precipitated on top of the asphalt liner and created sludge with soils that found their way into the basin via surface run off. The sludge, asphalt liner, and underlying soils visually stained by liquids that leaked through the liner were all transferred into the Basin F waste pile. During this transfer of the wastes from Basin F to the waste pile, samples of waste from each horizon were containerized in separate drums.

Three drums of containerized waste were analyzed. They were specifically targeted because each represented a unique horizon from Basin F (**Table A-1**). Two samples were collected and analyzed from the drum containing material below the liner.

Table A-1. Samples analyzed from the Basin F waste-pile material

Drum Number	Serial Number	Reported Origin
24074	F 913727	Waste Pile
41154	F 913728	Material Below Liner
41154	F 913732	Material Below Liner
99312	F 913527	“Sludge” Above Liner

Except for the sample from drum number 24074, the analyses from the remaining samples are characterized by relatively high non-detects. Only 1,2,3,4,6,7,8-H_pCDD (680 ppt in drum 99312), OCDD (8,400 ppt in Drum 99312 and 790 and 540 ppt in drum 41154, respectively) and

OCDF (1,400 ppt in Drum 99312) were above the detection limits. PCDD/F analyses from Basin F are shown in **Table A-2**.

Table A-2. PCDD/F analyses of Basin F waste-pile material

Congener	WHO TEF	Drum No. 24074 Conc. (ppt)	Serial No. F 913727 Conc. TEQ_{full}	Drum No. 41154 Conc. (ppt)	Serial No. F 913728 Conc. TEQ_{full}	Drum No. 41154 Conc. (ppt)	Serial No. F 913732 Conc. TEQ_{full}	Drum No. 99312 Conc. (ppt)	Serial No. F 913527 Conc. TEQ_{full}
2,3,7,8-TCDD	1.0	< 12	6	< 75	37.5	< 96	48	< 98	49
1,2,3,7,8-P_eCDD	1.0	14	14	< 140	70	< 140	70	< 200	100
1,2,3,4,7,8-H_xCDD	0.05	< 26	0.65	< 220	5.5	< 250	6.25	< 260	6.5
1,2,3,6,7,8-H_xCDD	0.01	110	1.1	< 160	0.8	< 180	0.9	< 190	0.95
1,2,3,7,8,9-H_xCDD	0.1	58	5.8	< 220	11	< 250	12.5	< 260	13
1,2,3,4,6,7,8-H_pCDD	0.001	770	0.77	< 180	0.09	< 260	0.13	680	0.68
OCDD		7,700		790		540		8,400	
2,3,7,8-TCDF	1.0	22	22	< 86	43	< 82	41	< 130	65
1,2,3,7,8-P_eCDF	0.1	16	1.6	< 140	7	< 140	7	< 250	12.5
2,3,4,7,8-P_eCDF	1.0	12	12	< 150	75	< 150	75	< 260	130
1,2,3,4,7,8-H_xCDF	0.1	54	5.4	< 140	7	< 170	8.5	< 180	9
1,2,3,6,7,8-H_xCDF	0.1	20	2	< 110	5.5	< 130	6.5	< 140	7
1,2,3,7,8,9-H_xCDF	0.1	24	2.4	< 160	8	< 200	10	< 210	10.5
2,3,4,6,7,8-H_xCDF	0.1	< 15	0.75	< 190	9.5	< 240	12	< 260	13
1,2,3,4,6,7,8-H_pCDF	0.01	290	2.9	< 130	0.65	< 140	0.7	< 330	1.65
1,2,3,4,7,8,9-H_pCDF	0.01	62	0.62	< 180	0.9	< 200	1	< 260	1.3
OCDF	0.0001	1,000	0.1	< 260	0.013	< 260	0.013	1,400	0.14
Total TEQ_{full}			**78.09**		**281.453**		**299.493**		**420.22**
Total TEQ_{quant}[a]			**70.7**		**0.0**		**0.0**		**0.8**

[a] Because the method detection limits were not reported for congeners with detections, method quantitation limits could not be calculated. Therefore, TEQ_{quant} was calculated by setting any result with a " < " designation to zero and includes the full value for any detected congener.

None of the four *coplanar* PCBs analyzed in the Tier 1 Field Study (PCB-77, -81, -126, and -169) were analyzed by EcoLogic (1996). Three of the eight *mono-ortho* PCBs were analyzed. PCB-105, -118, and -189 were each found to be below 1 μg/g (ppm) in all three drums. These data are of limited usefulness because of the high detection limits. Detection limits for the current study are in ppt.

Biota Samples

The biological samples from the CDPHE study were found dead on RMA from 1989 through the end of 1991 and collected by various U.S. Army and U.S. Fish & Wildlife Service personnel (**Table A-3**). They were tagged and stored frozen on site until June 6, 1995, when they were transferred to State of Colorado freezers to make room for additional USFWS samples.

Table A-3. Summary of biota samples obtained by the State of Colorado

Species	Date Collected	Comments with the Specimens
Great Horned Owl	10/15/90	Near orange and white tank at South Plants, electrocution
Great Horned Owl and Mouse	07/15/91	NW corner visitor center, electrocution
Great Horned Owl	03/22/91	Hydrazine Plant, #322, electrocution
Red-Tailed Hawk w/ 13-Lined Ground Squirrel	10/01/90	Electrocution on power pole near Basin F tanks
Canada Goose	06/18/90	Bldg. 111 front lawn, killed by coyote
Cottontail	05/03/90	Road kill on 8th Ave. by Basin A
13-Lined Ground Squirrel	?	900518, Basin F sludge pile, live trapped and euthanized
Muskrat	03/22/91	Lake Ladora dam, drowned in trap net
Deer Mice (3)	08/09/91	Basin F waste pile, cervical dislocation,
Blue-Winged Teal	04/25/89	Male, found near A Pond, Basin F, had flown into fence. Cause of death: euthanasia cervical dislocation
Ring-Necked Pheasant	4/25/89	Female, found west side of Tank 1, Basin F, possible death caused by flying into tank
Ring-Necked Pheasant	04/20/90	Female, off road in front of Bldg. 111, possible road kill (rigor mortis)
Kingbird	07/30/90	7th Ave. between Bldg. 111 and fire station, cause of death, road kill, broken neck
Ring-Necked Pheasant	05/09/90	Cause of death, flew into Basin F Tank #3
Cave Myotis or Big Brown Bat	04/13/90	Sec. 26 Basin F waste pile
House Finch	09/24/91	No information

From the biota samples collected, samples from five species were analyzed: three great horned owls, a red-tailed hawk, a 13-lined ground squirrel, three deer mice, and a big brown bat or cave myotis. Each owl and the red-tailed hawk were analyzed by tissue, including the liver, brain, skeletal muscles, and adipose (when available). The other species were homogenized for individual whole-body analyses. The three deer mice were homogenized into one sample. In general, the PCDD/Fs found in the great horned owls led to their inclusion in the current study.

For the owls and red-tailed hawk, the relative concentrations of PCDD/Fs between tissue samples is distributed in the following order:

Adipose > Liver > Skeletal > Brain,

when all tissues were available for analysis. The owl collected on 10/15/90 was emaciated. Three of the owls in the current study were also emaciated which led, in part, to the focus on owl livers. **Table A-4** presents the PCDD/Fs and *coplanar* PCBs for the three owls and the red-tailed hawk from the EcoLogic (1996) report. The emaciated owl has the greatest TEQs compared to the non-emaciated owls. This is consistent with the trend found in the owls of the current study. Dividing the total TEQ of the emaciated owl liver by the 8-fold factor applied to the owls of the current study yields an adjusted total TEQ of 86.1 ppt. Based on a reproductive-success endpoint, the toxicity benchmarks for adult-owl livers range from 14 ppt ($MATC_{NOAEL}$) to 230 ppt ($MATC_{LOAEL}$) (BAS 2000, Appendix E). Thus, it is possible that PCDD/Fs were sufficiently elevated to have an effect on this owl and the other two owls. The *mono-ortho* PCBs add a negligible fraction to the total TEQs for all species analyzed (**Tables A-4 and A-5**).

Moreover, the congener patterns of PCDD/Fs appear to be consistent between the Basin F material and the biota analyses. In general, *penta*-dioxin, and *penta*- and *hepta*-furans are the predominant congers that contribute to the total TEQ concentrations.

Table A-4. Liver PCDD/F and *mono-ortho* PCB concentrations in great horned owls and a red-tailed hawk

		Great Horned Owls						***Red Tail Hawk***	
		7/15/91		**3/22/91**		**10/15/1990***		**10/1/91**	
Congener	**WHO TEF**	Conc. (ppt)	TEQ_{full}	Conc. (ppt)	TEQ_{full}	Conc. (ppt)	TEQ_{full}	Conc. (ppt)	TEQ_{full}
2,3,7,8-TCDD	1.0	0.9	0.9	0.93	0.93	1.3	1.3	0	0
1,2,3,7,8-P_eCDD	1.0	5	5	9.8	9.8	16	16	3.2	3.2
1,2,3,4,7,8-H_xCDD	0.05	3.5	0.175	14	0.7	36	1.8	8.5	0.425
1,2,3,6,7,8-H_xCDD	0.01	12	0.12	81	0.81	100	1	17	0.17
1,2,3,7,8,9-H_xCDD	0.1	0.95	0.095	2.7	0.27	15	1.5	5.5	0.55
1,2,3,4,6,7,8-H_pCDD	0.001	14	0.014	38	0.038	270	0.27	310	0.31
OCDD		17	0	52	0	140	0	560	0
2,3,7,8-TCDF	1.0	1.8	1.8	0	0	2	2	0	0
1,2,3,7,8-P_eCDF	0.1	1.1	0.11	6.5	0.65	78	7.8	0	0
2,3,4,7,8-P_eCDF	1.0	11	11	41	41	260	260	0	0
1,2,3,4,7,8-H_xCDF	0.1	36	3.6	370	37	2500	250	5.6	0.56
1,2,3,6,7,8-H_xCDF	0.1	18	1.8	150	15	1,200	120	4	0.4
2,3,4,6,7,8-H_xCDF	0.1	3.9	0.39	15	1.5	74	7.4	5.1	0.51
1,2,3,7,8,9-H_xCDF	0.1	6.3	0.63	0	0	47	4.7	0	0
1,2,3,4,6,7,8-H_pCDF	0.01	7.3	0.073	69	0.69	990	9.9	98	0.98
1,2,3,4,7,8,9-H_pCDF	0.01	3	0.03	100	1	500	5	4.9	0.049
OCDF	0.0001	5.6	0.00056	170	0.017	0	0	17	0.0017
Total TEQ (PCDD/PCDFs)			**25.74**		**109.41**		**688.67**		**7.16**
233'44'PeCB (105)	0.0001	< 8.0	0.0004	< 8.0	0.0004	< 9.0	0.00045	<8.0	0.0004
2'344'5PeCB (118)	0.0001	< 8.0	0.0004	< 8.0	0.0004	25	0.0025	<8.0	0.0004
233'44'55'HpCB (189)	0.0001	< 10.0	0.0005	< 10.0	0.0005	< 10.0	0.0005	<10.0	0.0005
Total TEQ (PCDD/PCDFs and PCBs)			**25.74**		**109.41**		**688.67**		**7.16**

***** emaciated

Table A-5. Whole-body PCDD/F and *mono-ortho* PCB concentrations for a 13-lined ground squirrel, three mice, and a bat

		13-Lined Ground Squirrel		Three Deer Mice		Big Brown Bat	
	WHO TEF	5/18/90		8/9/91		9/13/90	
		Conc. (ppt)	TEQ_{full}	Conc. (ppt)	TEQ_{full}	Conc. (ppt)	TEQ_{full}
Congener							
2,3,7,8-TCDD	1.0	< 0.61	0.305	< 0.57	0.285	1.4	1.4
1,2,3,7,8-P_eCDD	1.0	1.1	1.1	1.5	1.5	5.1	5.1
1,2,3,4,7,8-H_xCDD	0.05	2.1	0.105	1.3	0.065	3.6	0.18
1,2,3,6,7,8-H_xCDD	0.01	15	0.15	1.2	0.012	9.1	0.091
1,2,3,7,8,9-H_xCDD	0.1	< 0.97	0.0485	2.4	0.24	2.2	0.22
1,2,3,4,6,7,8-H_pCDD	0.001	2.3	0.0023	5.9	0.0059	41	0.041
O_8CDD		4.7	0	38	0	66	0
2,3,7,8-TCDF	1.0	< 0.55	0.275	< 0.55	0.275	< 1	0.5
1,2,3,7,8-P_eCDF	0.1	< 1.5	0.075	< 0.64	0.032	< 1	0.05
2,3,4,7,8-P_eCDF	1.0	< 1.5	0.75	< 0.63	0.315	2.2	2.2
1,2,3,4,7,8-H_xCDF	0.1	< 0.56	0.028	0.78	0.078	3.6	0.36
1,2,3,6,7,8-H_xCDF	0.1	0.53	0.053	1	0.1	2.6	0.26
2,3,4,6,7,8-H_xCDF	0.1	< 0.65	0.0325	1.3	0.13	< 3.3	0.165
1,2,3,7,8,9-H_xCDF	0.1	< 0.68	0.034	1.2	0.12	< 1.1	0.055
1,2,3,4,6,7,8-H_pCDF	0.01	< 1.2	0.006	2.6	0.026	4.5	0.045
1,2,3,4,7,8,9-H_pCDF	0.01	< 1.4	0.007	3.1	0.031	< 2.4	0.012
OCDF	0.0001	< 1.3	0.000065	32	0.0032	4.2	0.00042
Total TEQ (PCDD/PCDFs)			**2.97**		**3.22**		**10.68**
233'44'PeCB (105)	0.0001	< 8.0	0.0004	< 8.0	0.0004	< 10.0	0.0005
2'344'5PeCB (118)	0.0001	< 8.0	0.0004	< 8.0	0.0004	35	0.0035
233'44'55'HpCB (189)	0.0001	< 10.0	0.0005	< 10.0	0.0005	< 10.0	0.0005
Total TEQ (PCDD/PCDFs and PCBS)			**2.97**		**3.22**		**10.68**